



Arctic Gas

Report to

CANADIAN ARCTIC GAS STUDY LIMITED

on

1975 Activities of the

WASTE HEAT RECOVERY --

GREENHOUSE VEGETABLE PRODUCTION PROJECT

University of Saskatchewan

February 25, 1976

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UNIVERSITY OF SASKATCHEWAN WASTE HEAT RECOVERY --
GREENHOUSE VEGETABLE PRODUCTION PROJECT
PROGRESS REPORT 1975

During 1975, the team working on this project have undertaken a great deal of work and gained considerable experience. At the present time, the project is in the late stages of Phase II of the four major phases.

Phase I - Preliminary studies to determine the feasibility of the project.

Phase II - Construction of a pilot greenhouse to establish the physical and economic feasibility of the concept.

Phase III - Construction of pilot commercial-sized greenhouses, based on the findings in Phase II, to substantiate the commercial feasibility of this project.

Phase IV - Construct a commercial-sized greenhouse range and develop programs for plant growth in this unique type of structure.

A number of major engineering and horticultural facts have been revealed using the facility described in the last report. They are as follows:

ENGINEERING

- (a) Exhaust gases from a turbine fired by natural gas (without odorant) can heat and provide high levels of carbon dioxide for enhanced growth of tomatoes.

- (b) Greenhouses can be heated by passing the hot exhaust gases between a double layer of polyethylene covering the greenhouse. This method results in a substantial reduction in capital and operating costs.
- (c) Uniform temperature and air velocity distribution can be obtained in this greenhouse.
- (d) Turbine exhaust gases cannot be fed directly into the greenhouse without some form of filtering to reduce the nitrogen oxide (NO_x) content to a level that can be tolerated by plants and man.
- (e) A suitable filter system has been developed and forwarded to Canadian Patents Development Limited. We have been informed that they are proceeding with a patent application.
- (f) Other gases in the exhaust (SO_2 and CO), under the conditions of this experiment, are not present in sufficient quantities to be a problem to plants or man.

HORTICULTURE

- (a) Tomatoes can be satisfactorily grown in plastic bags containing artificial media (sawdust) that is wetted at regular intervals with a nutrient solution.
- (b) Tomatoes will not tolerate nitrogen dioxide (NO_2) levels of .5 ppm or higher and nitric oxide (NO) levels of 1.5 ppm or higher.
- (c) Carbon dioxide levels from 1500 to 5000 ppm do not cause any visible injury to tomato plants.
- (d) Carbon dioxide enrichment up to 5000 ppm throughout the entire day, rather than just the normally recommended daylight period



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do not cause any visible injury to tomato plants.

- (e) Tomato plants grown in the greenhouse sections heated by exhaust gases consistently produced more fruit than a corresponding check section.
- (f) Carbon dioxide enrichment allowed good quality tomatoes to be produced during the low-light period of the year without employing artificial light. There were indications that the good growth observed during winter was the result of carbon dioxide compensating for the low light intensities.
- (g) Under low-light conditions of winter, carbon dioxide enrichment appeared to be responsible for increasing the number of fruit matured per truss.
- (h) Growing the plants on raised beds facilitated air movement and thus uniform temperatures within the greenhouse.
- (i) The high relative humidity that resulted in the greenhouse sections heated with waste heat created the need for a continuous disease control program.
- (j) High quality tomatoes can be produced that are equal or superior to imported field-grown fruit.
- (k) It would appear that locally-grown tomatoes can command a premium price.

In the course of our work, we have recognized a number of major engineering and horticultural questions that need to be answered. We are presently attempting to solve those that must be answered before proceeding to the next phase of our project.

ENGINEERING

It is not known whether the capital costs of conveying and controlling hot exhaust gases will allow production of tomatoes or other greenhouse vegetables.

HORTICULTURE

- (a) Crop production, capital and operating costs have not been evaluated on a commercial scale.
- (b) The optimum levels of carbon dioxide to give a maximum yield under various combinations of daylength, temperature, and nutrition have not been determined under prairie conditions. Further, the influence of continuous high levels of carbon dioxide on plants as compared to the fluctuating levels normally recommended remains to be determined. It is possible that some of the observed better growth is due to an improvement of environmental factors such as air temperature, air movement and polyethylene-surface temperature.
- (c) The improvement in growth and yield obtained at a turbine site that operates year round.
- (d) The response of tomato varieties other than Michigan-Ohio.
- (e) Quality analysis should be conducted to compare local greenhouse-grown fruit and field grown imports.
- (f) The response of greenhouse vegetable crops such as cucumbers, lettuce, radishes and peppers.

Our analysis of results obtained to date lead us to conclude that the utilization of exhaust gases from a 1100 hp solar gas-fired turbine

for greenhouse heating and carbon dioxide enrichment have proven successful enough to warrant consideration of a pilot, commercial-sized operation utilizing a source that runs year round. In order to consider the engineering of such a project, George Green has made several aspects of it into an academic project for a 4th year engineering class. They are using the layout for the Saskatchewan Power Corporation Compressor Station at Success, Saskatchewan. It has 3 turbines similar to the one utilized at the Saskatoon Compressor Station. The two graduate students working on the Saskatoon project are involved in designing the horticultural requirements for this project. It is hoped that the economic feasibility of this project can be evaluated early this spring.

Maynard Haukeness, the graduate student who has been with us since the beginning of the Saskatoon project will complete his M.Sc. requirements this spring. In order to give some continuity between students, we were fortunate to have Ken Miller start his M.Sc. program in early January, 1976. Both of these students show a high degree of interest in engineering and thus we have had no trouble adapting them to our horticulture-engineering project.

In October 1975, two members of the team (Maginnes and Brooks) were invited to attend and participate in an international workshop on Low-Grade Heat: A Resource in Cold Climates. It was held at the Chalk River Nuclear Laboratories, Chalk River, Ontario. This conference attempted to present information on all the known projects, constructed or planned, that utilize waste energy. The Saskatoon project would appear to be unique in that it was the only project

reported that utilizes exhaust gases, more or less directly, for heating and carbon dioxide enrichment of greenhouses.

A number of broad descriptive statements have been released on the Saskatoon project, but no detailed papers. It has been suggested by Canadian Patents Development Ltd., that release of detailed information be withheld until a final decision has been made on patenting of the concept used in our greenhouse.

